

PATENT APPLICATION  
"NAVIGATION MORSE DECODE DISPLAY"

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## NAVIGATION MORSE DECODE DISPLAY

This application claims the benefit of U.S. Provisional Application Serial  
5 No. 60/217,057, filed in the names of William G. Sample, David L. Biddick, and  
Richard Bontrager on July 10, 2000, the complete disclosure of which is incorporated  
herein by reference.

### FIELD OF THE INVENTION

The present invention is directed to communication and navigation  
10 devices for aircraft and, more particularly, to an aircraft communication and navigation  
device that decodes a Morse code, correlates the decoded Morse code to a known  
station, and displays the station information on a cockpit display.

### BACKGROUND OF THE INVENTION

Modern aircraft pilots must send and receive information to and from a  
15 large number of facilities. In particular, VHF radio signals are used by aircraft pilots for  
navigation. For example, VOR's (VHF Omni-directional ranges), localizers, LDA's,  
and SDF's are VHF radio signals that operate within the 108.00 to 117.95 MHz  
frequency band and have a power output necessary to provide coverage within an  
assigned operational service volume. The VHF navigation facilities that generate the  
20 VHF radio signals are subject to line-of-sight restrictions, and the range varies  
proportionally to the altitude of the receiving equipment.

Aircraft pilots are instructed to listen to the Morse Code identification of  
radio navigation stations to verify the correct VHF navigation facility has been tuned  
and that it is sending valid information. Most VOR facilities are equipped for voice  
25 transmission on the VOR frequency. VOR facilities without voice capability are  
indicated on navigation charts by an underline of the facility frequency. The voice  
capability may be used for two way communication with aircraft, for transmission of

recorded flight information and for voice identification of the navigation station. Many Flight Service Stations (FSS) (or approach control facility) remotely operate several omniranges with different names. In some cases, none of the VOR facilities have the name of the "parent" FSS. Therefore, reliance on voice transmissions by the FSS

5 involved for determining the identification of an omnirange is risky. During periods of maintenance, the facility may radiate a T-E-S-T code (- • • • -) or the code may be removed. The only positive method of identifying a VHF navigation facility is by decoding its Morse code identifier or monitoring the voice identification.

During operation of the aircraft, the pilot must identify the VHF  
10 navigation facility by mentally decoding an audio Morse code signal transmitted by the facility. Many pilots are not adept at performing this decoding operation, which often has to be performed during a high workload phase of flight. A single check, by the pilot, of the code at first use of the facility is not sufficient to detect a problem later in the flight. Continuous monitoring is necessary for the highest level of safety.

15 Systems that provide a radio Morse code identification function are in use and display the identification information in monochrome displays. While useful, such systems have limited functionality. Known Morse code identification systems typically sample the VHF navigation identifier at least twice to increase confidence of a correct decode. This increases the time before the identifier may be displayed to the  
20 pilot. Also, known Morse code identification systems do not correlate the decoded Morse code identifier with a specific VHF navigation facility, instead known systems only display a visual representation of the Morse code itself. When unable to decode the Morse signal, existing systems merely "dash" the display. These limitations increase the pilot's workload, and detract from safe aircraft operation and navigation.

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#### SUMMARY OF THE INVENTION

The present invention overcomes the limitations of the prior art by providing a device in the cockpit that reduces pilot workload by automating decoding of

the Morse code identifier and using an onboard database to correlate the decoded Morse code identifier with a specific VHF navigation facility.

The present invention also provides continuous monitoring, in contrast to prior art systems that rely on a single check by the pilot.

5           The development of inexpensive large format color displays and inexpensive memory for information storage make practicing the present invention feasible for aircraft. One embodiment of the present invention is sized for installation and operation in small business and general aviation aircraft.

10           The present invention provides a display device that includes a display having a first input structured to receive a radio frequency control signal and a second input coupled to receive radio frequency information, the display structured to display one of the radio frequency information and caution information in response to a signal received on a third input; a radio receiver having a first input coupled to receive the radio frequency control signal and a second input coupled to receive a radio frequency  
15   signal having an identifier coded in Morse code, the radio receiver outputting the coded identifier; a memory device having a first input coupled to receive the radio frequency control signal and a second input coupled to receive a position signal, the memory device having a circuit for correlating the radio frequency control signal and the position signal with a database of radio frequency identifiers to select and output on a  
20   first output one of the radio frequency identifiers and to select and output on a second output coupled to the second input of the display radio frequency information corresponding to the selected one of the radio frequency identifiers; and a processor having a first input coupled to receive the output of the radio receiver to receive the coded identifier and a second input coupled to the output of the memory device to  
25   receive the selected one of the radio frequency identifiers, the processor operating one or more algorithms for decoding the coded identifier, for comparing the decoded identifier with the selected one of the radio frequency identifiers, and for generating a signal on an output coupled to the third input of the display as a function of the comparing.



According to yet other aspects of the invention, the invention provides a method or algorithm for decoding a radio signal identifier, or identification string, in a Morse coded radio frequency signal using, for example, the decoder of the invention.

#### BRIEF DESCRIPTION OF THE DRAWINGS

5           The foregoing aspects and many of the attendant advantages of this invention will become more readily appreciated as the same becomes better understood by reference to the following detailed description, when taken in conjunction with the accompanying drawings, wherein:

          Figure 1 shows a particular embodiment of a front face of a navcomm  
10   device whereupon a Morse code identifier is displayed after it is decoded and correlated with a specific VHF navigation facility using an onboard database;

          Figure 2 illustrates an exemplary block diagram of one embodiment of the Morse signal decoder and identifier device of the invention;

          Figure 3 is an exemplary display of navigation frequency identification  
15   before successful Morse decoding;

          Figure 4 is an exemplary display of navigation frequency identification illustrating the display following successful Morse decoding wherein the decoded Morse identifier matches the database identifier;

          Figure 5 is an exemplary display of navigation frequency identification  
20   illustrating the display following successful Morse decoding wherein the decoded Morse identifier does not match the database identifier;

          Figure 6 is a flow chart that illustrates one embodiment for implementing in a processor the algorithm of the invention for decoding in a single pass the identification string in a received Morse code radio frequency signal; and

25           Figure 7 illustrates a state chart used by a viterbi MSLE in the operation of a viterbi most-likely sequence estimator on the outputs of a presence detector during operation of the algorithm of the invention illustrated in Figure 6.

## DETAILED DESCRIPTION OF PREFERRED EMBODIMENT

In the Figures, like numerals indicate like elements.

The present invention is a device that receives a Morse code signal from a radio navigation station, decodes the signal, and correlates the decoded signal to a known station, the information for which is stored in an onboard database. The station information is displayed on a cockpit color display.

The present invention integrates a navigational database and a real time digital decoder to process navigation radio Morse code information. The device automates the decoding process, such that no explicit actions are required to enable device operation. The simple tuning of a radio frequency causes a database search for the most likely identifier based upon the current aircraft location.

Figure 1 shows a particular embodiment of a front face of a navcomm device 10 whereupon a Morse code identifier is displayed after it is decoded and correlated with a specific VOR facility using an onboard database. The navcomm device 10 includes a control panel 12 and a display 14. The control panel 12 includes a VOR localizer (VLOC) frequency transfer switch 26, and a VLOC volume/ID control 30 for controlling volume. The control panel 12 also includes other controls that are well-known, but are not relevant to the present invention and are not described.

Display 14 includes a left side display portion 62 on which the displays of navigation frequency identification of the invention are provided. Display 14 also includes a right side display portion 66 having displays that are not relevant to the present invention and are not described. The contents of the left side display portion 62 depends upon the set display mode for navcomm device 10. The display modes relevant to this invention include a standby frequency entry mode and an active frequency entry mode. These different display modes will be discussed in more detail below.

The left side display portion 62 includes a COM frequency display 70, a VLOC frequency display 74, a distance measuring equipment (DME) display 78, and a GPS display 82. The COM frequency display 70, DME display 78, and GPS display 82 are not relevant to the present invention and are not described.

The VLOC frequency display 74 typically displays an active VLOC frequency 94 (shown as 113.00 in this example) and a standby VLOC frequency 98. Indicated together with the active VLOC frequency 94 is the station identifier (OJC in this example) to the right of the frequency, the direction (230° in this example) to or from (FR in this example) the facility above the VOR station identifier, and the facility name (Johnson Co) below the frequency. Indicated together with the standby VLOC frequency 98 is the station identifier (IIXD in this example) to the right of the frequency and the facility name (New Century) below the frequency.

A concentric control device 38 whereby the pilot enters a VLOC frequency 94. The concentric control device 38 has a rotatable outer knob 42, a rotatable inner knob 46 and a centrally disposed push button 50. The standby VLOC frequency 98 is set using the concentric control device 38. A megahertz portion of the standby VLOC frequency 98 is set between 108 and 117 by rotating outer knob 42, and the kilohertz portion of the standby VLOC frequency 98 is set between 00 and 95 by rotating inner knob 46 of concentric control device 38, so that the standby VLOC frequency 98 is set within the 108.00 to 117.95 MHz frequency band. The pilot selects a standby VLOC frequency 98 that matches the desired VOR facility indicated on the navigation chart. The VLOC frequency transfer switch 26 transfers the standby VLOC frequency 98 to the active VLOC frequency 94 so that the navigation receiver (shown in Figure 2) can receive on the VLOC frequency 94.

The Morse code navigation signal from a radio navigation station operating on the VLOC frequency 94 is received, decoded, and correlated to a known VHF navigation station, the information for which is stored in an onboard database. The VHF navigation station information is then displayed on a cockpit color display.

Figure 2 illustrates an exemplary block diagram of one embodiment of the Morse code decoder and identifier device 100 of the invention. The Morse code decoder and identifier of the invention can be implemented in any number of configurations, and the block diagram of Figure 2 is only one exemplary embodiment, which is not intended to in any way limit the scope of the invention or its equivalents.



In Figure 2, the radio frequency of a desired VHF radio navigation station navigation station, for example a VOR station, is entered on the navcomm device 10 using the outer knob 42 and the inner knob 46 of the concentric control device 38 to tune the standby VLOC frequency 98 at the frequency indicated on the navigation chart. The standby VLOC frequency 98 is displayed on the display 14, as shown in Figure 3. At an appropriate time, the pilot transfers the standby VLOC frequency 98 to the active VLOC frequency 94 using the VLOC frequency transfer switch 26. The VLOC frequency 98 is simultaneously input to the navigation receiver 114, which begins to receive the VHF navigation signal via the antenna 116. The VHF navigation signal is received in Morse code and input to a processor 118, such as a digital signal processor, which operates an algorithm, described below, that decodes the received Morse code identifier in a single pass. The processor 118 is alternatively a dedicated processor or another processor located elsewhere in the aircraft, which may be shared by other functions.

The frequency of the desired VOR station is also input to a lookup table of VHF navigation stations stored in an onboard memory device as a navigation database 120. Current aircraft location data is retrieved from an onboard global positioning system (GPS) 122. The database is searched, and the most likely identifier is predicted based upon the current aircraft location. For example, using both the input frequency and the GPS location data, the identifier of the VOR facility closest to the aircraft's present location is located in the navigation database 120 using the input frequency. The "predicted" identifier is passed to the digital signal processor 118, and the information from the navigation database 120 is displayed near the entered frequency, as shown in Figure 3.

The algorithm operated on the digital signal processor 118 compares the decoded identifier received over the navigation receiver 114 with the identifier predicted by the navigation database 120. The algorithm operated on the digital signal processor 118 identifies one of the following conditions: (1) the identifier received from the navigation station corresponds to and is the predicted identifier; (2) no identifier is currently being received from the navigation station; and (3) an identifier which does

not correspond to and is not the predicted identifier was received from the navigation station.

Figure 3 is an exemplary illustration of the display 14 showing navigation frequency identification information before the Morse signal is successfully decoded. The navigation frequency identification information 124 from the navigation database 120 is displayed near the entered frequency, as shown in Figure 3, in the same color as the active VLOC frequency 94, for example, white.

As shown in Figure 4, after the Morse code identifier is successfully decoded, it is compared with the predicted identifier from the navigation database 120. If the received and predicted identifiers match, the identifier 124 displayed on the display 14 changes to a different color, such as green (not shown), that indicates a successful match.

As shown in Figure 5, if the decoded identifier does not match the predicted identifier from the navigation database 120, then the decoded identifier is displayed as the identifier 124 in a color, such as yellow (not shown), that conveys caution or warning.

Figure 6 is a flow chart that illustrates one embodiment for implementing in a processor 118 (shown in Figure 2) the algorithm of the invention that decodes the received Morse code identifier in a single pass. Of course, the algorithm of the invention is alternatively implemented by other equivalent means. The flow chart illustrated in Figure 6 is thus only one exemplary embodiment of the algorithm of the invention and is not intended to in any way limit the scope of the invention.

In Figure 6, the VHF radio frequency signal detected at the navigation receiver 114 via the antenna 116 and provided to the processor 118, which operates a Morse radio frequency signal identifier decoder 200 of the invention for decoding the detected Morse code identifier in a single pass. The detected VHF radio frequency signal is processed by a hardware bandpass filter 202, which is the hardware anti-alias filters and baseband decoding hardware for the decoder 200. The signal is analog-to-digital converted in a A/D (analog-to-digital) converter 204 operating at a suitable frequency, for example 3120 Hz.

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The digital signal is passed to a 26-times down-sampler quadrature filter bank 206 that converts the received signals into an in-phase and quadrature-phase signal, and reduces the sampling frequency to a more suitable level. For example, the 26-times down-sampler quadrature filter bank 206 reduces the sampling frequency from 3120 Hz to 120 Hz. The in-phase signal and quadrature signal are passed to respective down-sampler/multi-stage modulated filter bank 208a, 208b, that filters each of the respective in-phase and quadrature signals into multiple components and further reduces the sampling frequency. For example, the down-sampler is a 6-times down-sampler that reduces the sampling frequency from 120 Hz to 20 Hz, and the multi-stage modulated filter bank is an 8-stage modulated filter bank.

The in-phase and quadrature signals are passed to confidence presence detector 210 that searches across the plurality of filter components to determine which bank is likely to contain the identification string, i.e., the VHF radio frequency identifier. The presence detector 210 makes this determination by determining which signal has the most energy. The presence detector 210 creates a multi-level confidence indicator by comparing the most likely signal energy with the average energy in all the remaining filter stages. For example, the presence detector 210 is a 4-bit confidence presence detector 210 that determines which bank is likely to contain the identification string by searching across the eight filter components to determine which signal has the most energy, and then creates a 16-level confidence indicator by comparing the most likely signal energy with the average energy in all the remaining filter stages.

A viterbi MSLE 212 operates a viterbi most-likely sequence estimator on the outputs of the presence detector 210 using the state chart 213 shown in Figure 7.

A Morse symbol decoder 214 receives the output of the viterbi MSLE 212, converts the series of 1's and 0's into an estimate of the dot, dash, space and word locations in the detected signal, and outputs the result to an up-sampler 216 that converts the detected word into a series of 1's and 0's having a predetermined width of 1's per dot length. For example, the up-sampler 216 is a 3-times up-sampler that converts the detected word into a series of 1's and 0's whose width is three ones per dot length.

The navigation database 120 outputs the identification string of the predicted identifier of the desired VHF radio navigation station, for example a desired VOR station, to the processor 118. A Morse symbol encoder 218 encodes the predicted identification string into a series of dot, dash, space and word symbols. The encoded  
5 predicted identification string is operated upon by an up-sampler 220 that convert the detected word into a series of 1's and 0's having a predetermined width of 1's per dot length. For example, the up-sampler 220 is a 3-times up-sampler that converts the detected word into a series of 1's and 0's whose width is three ones per dot length.

A threshold estimator 222 estimates the signal energy in the encoded and  
10 up-sampled predicted identification string.

A correlator 224 correlates the detected and up-sampled Morse code symbols with the predicted Morse code symbols to determine whether the detected VHF radio frequency signal identifier corresponds to the predicted identifier. If a comparator 226 determines that the signal energy in the detected VHF radio frequency signal  
15 identifier exceeds the threshold estimate of the signal energy in the predicted identification string, then a VHF radio frequency signal identifier has been detected and the detected VHF radio frequency signal identifier corresponds to the predicted identifier, as shown in block 228. Given such positive identification, the result is transmitted to the navcomm device 10, and displayed on the front face thereof, as  
20 discussed above. The pilot is thus informed that the desired VHF radio navigation station has been detected.

If the comparator 226 determines that the signal energy in the detected VHF radio frequency signal identifier is less than the threshold estimate of the signal energy in the predicted identification string, then either a VHF radio frequency signal  
25 identifier has not been detected, or the detected VHF radio frequency signal identifier fails to corresponds to the predicted identifier. As shown in block 230, given such negative identification, the output of the viterbi MSLE 212 is output to a conventional Morse signal decoder (not shown) that uses the results of the Viterbi MLSE to attempt via time correlation to decode the detected identification string.

While the preferred embodiment of the invention has been illustrated and described, it will be appreciated that various changes can be made therein without departing from the spirit and scope of the invention.

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